Photogrammetry II

3rd Stage

Stereoscopic Viewing – lecture 2

Dr. Fanar Mansour

E-mail : fanar.mansour@london.com

Stereoscopic parallax - Review

- Parallax: is the apparent displacement in the position of object caused by a shift in the position of observation.
- The change in position of an image from one photograph to the next caused by the aircraft's motion is termed stereoscopic parallax, x parallax, or simply parallax.
- The parallax of any point is directly related to its elevation.
- Parallax is greater for high points than for low points.

NOTE:
Differentiate parallax (x parallax) from y parallax!

Stereoscopic parallax

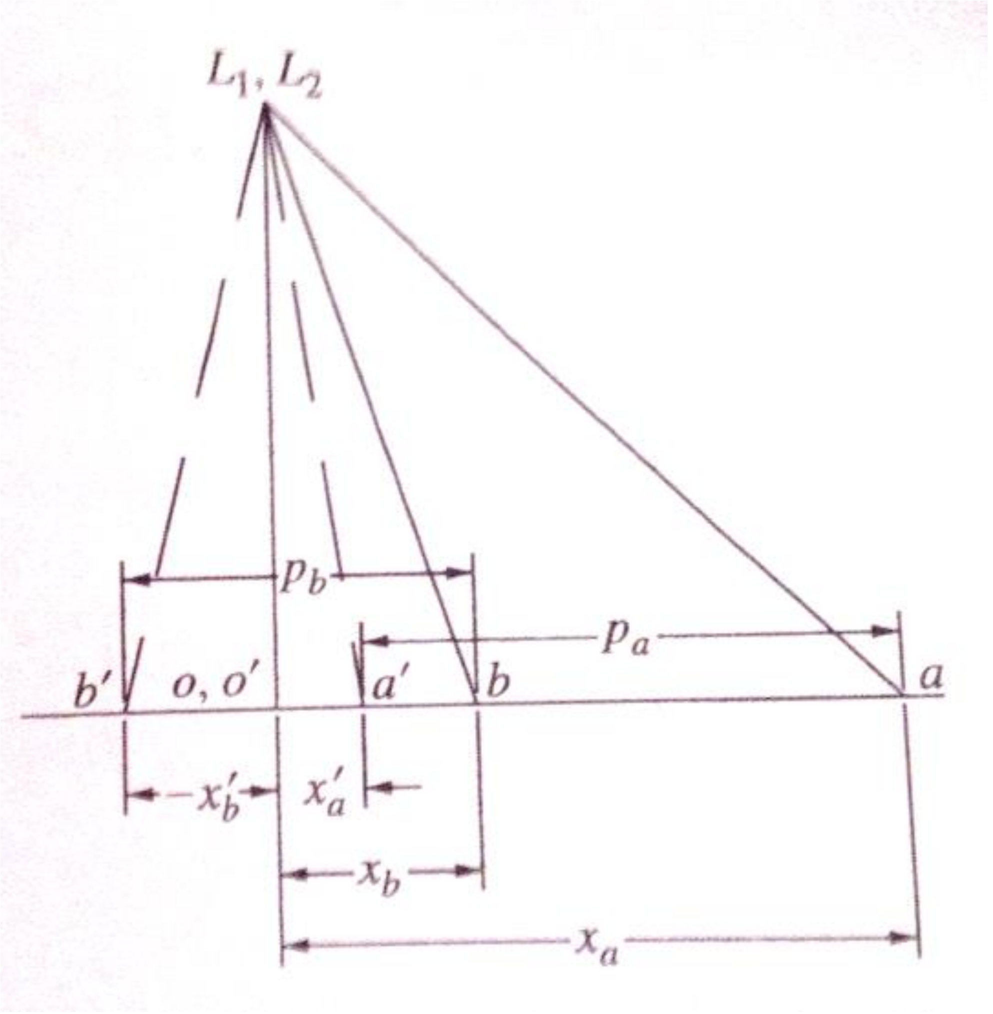
- Parallaxes of point A and B in the Fig. shown are p_a and p_b respectively.

- Stereoscopic parallax for any point such as A whose images appear on two photos of a stereo-pair can be expressed as follow:

$P_a = x_a - x'_a$

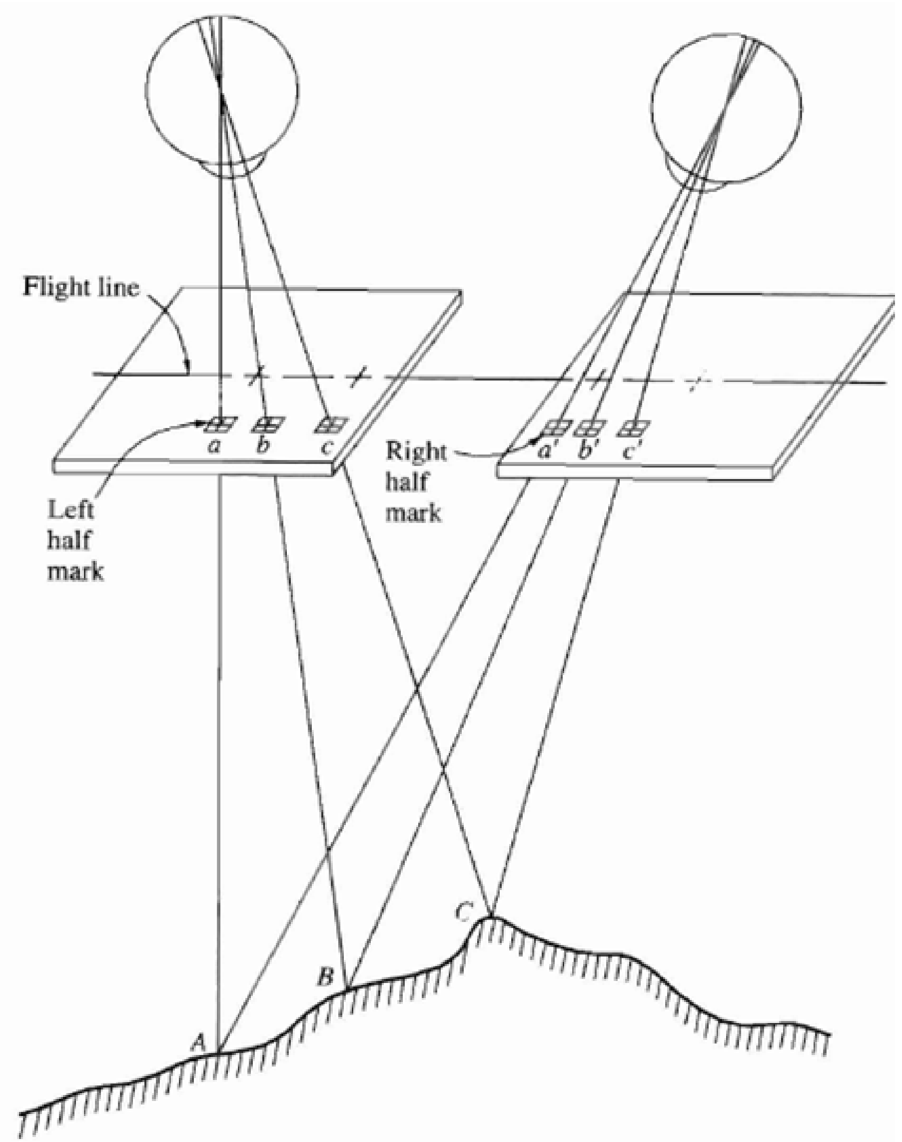
x_a is the measured photo coordinates of image a on the left photo
x'_a is measured photo coordinates of image a' on the right photo

Note: These photo coords. Are NOT measured with respect to principal point rather they are measured with respect to flight-line axis system.



Principal of the floating mark

- The measuring index in stereo is called a floating mark.
- A dot, or half a dot, that when rests on a location in the stereo model, the observer sees one mark instead of two
- The apparent height (Z) of the mark is related to the x separation of the point in photos, its parallax.



Monoscopic method of parallax measurements

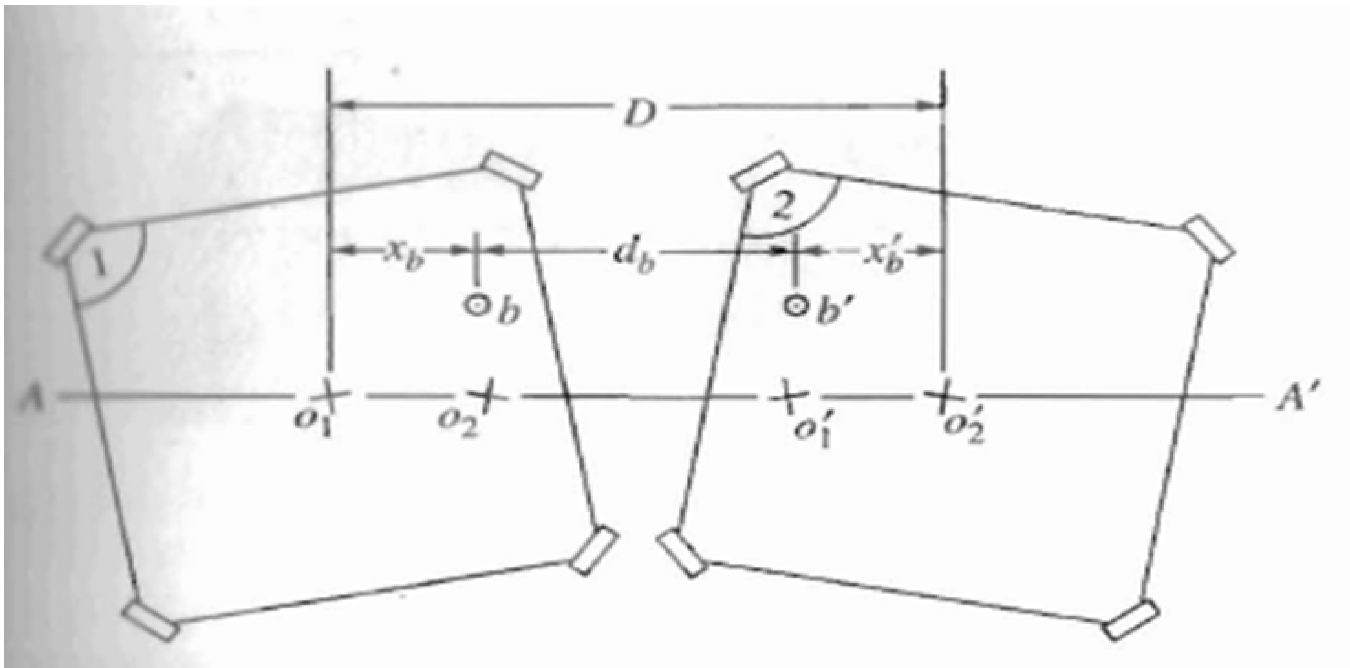
- Since x parallax is a function of relief or heights of points above datum, elevations of points can be computed by measuring their parallax.
- Other values can also be derived if unknown such as the flying height, or air base.
- To measure parallax of a point you can :

  a) Either measure in mono: measure the value of the x coordinate of the point on each photograph and subtract the left from the right value. For example, if point a appears on Left and right photos then:

  $$p_a = x_{aL} - x_{ar}$$

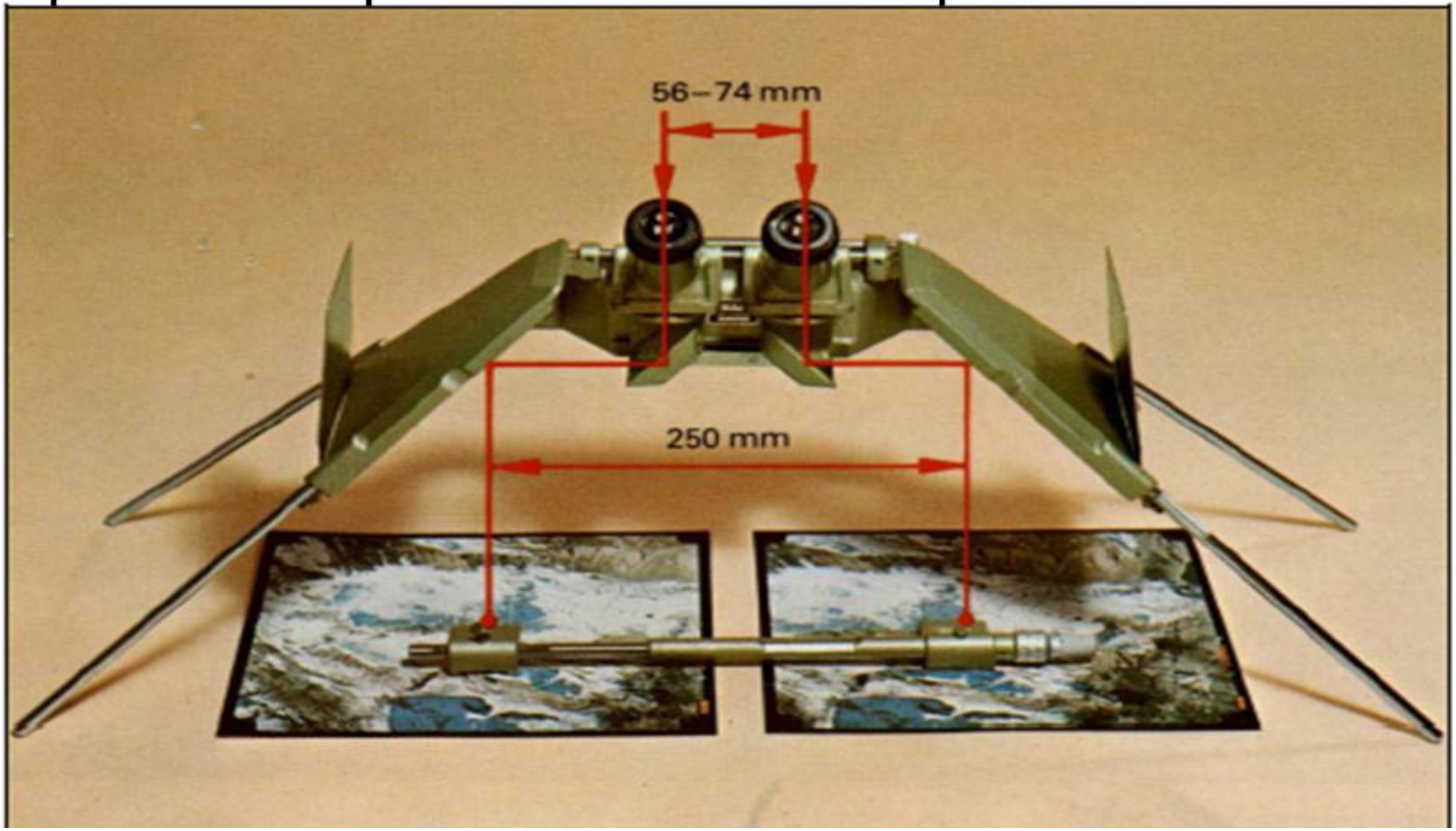
Monoscopic method of parallax measurements

- b) Or measure in stereo using a parallax bar. Put the photos on a table under a stereoscope, move them right and left up and down until you see comfortably in stereo, in this case: air base B as photo base b: o1 o2, and the center of the lenses of the device must be in the same direction

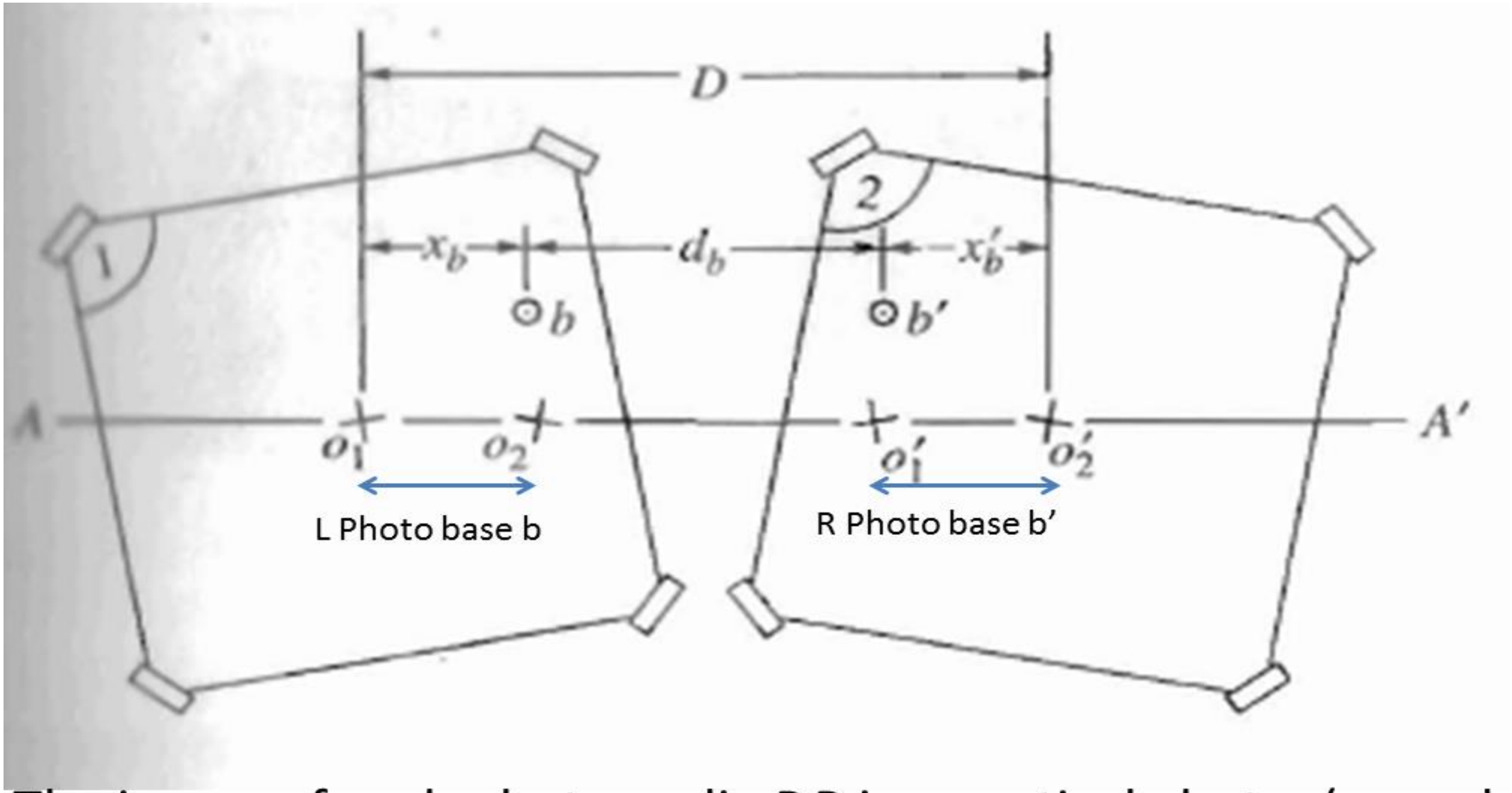


Measuring parallax with parallax bar

The parallax bar is a measuring device to measure the x parallax of points in a fast and precise manner.



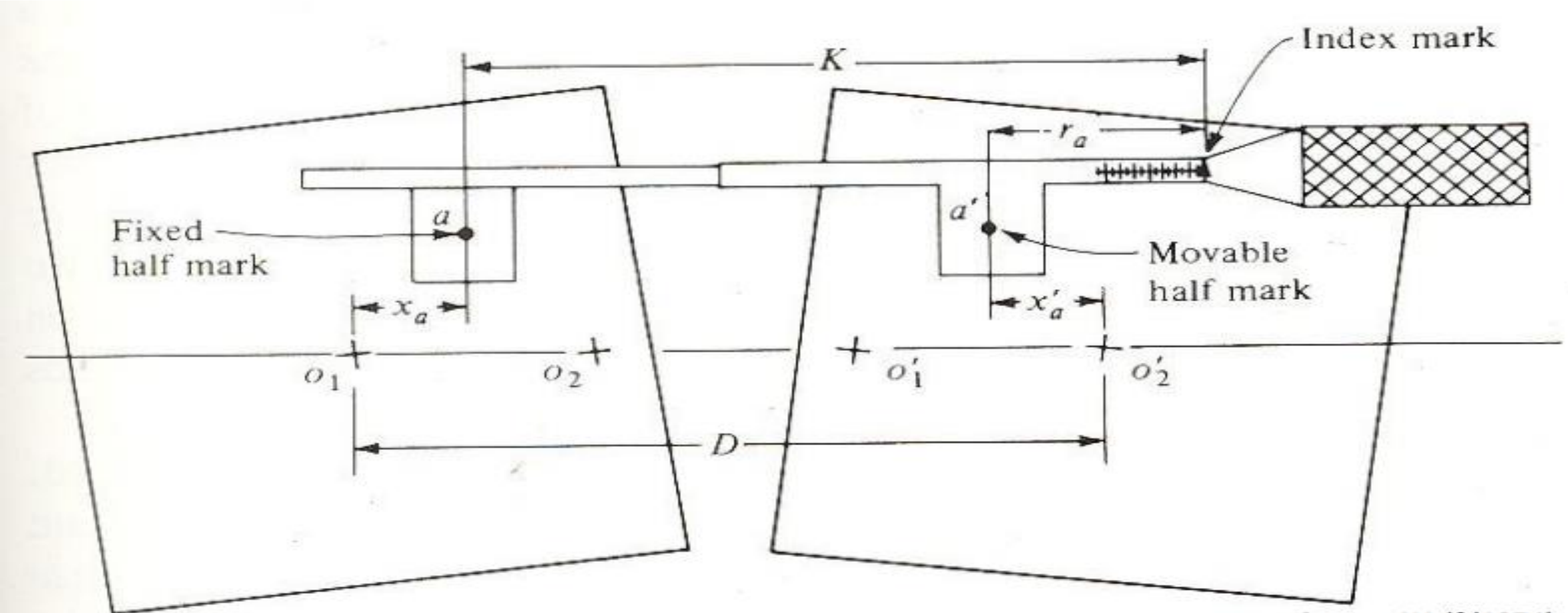
Measuring parallax with parallax bar



The image of each photo nadir, P.P in a vertical photo (o_1 and o_2')appears on the other photo

Parallax of b = D – d_b = x_b – x_b' note that x_b' is negative)

Measuring parallax with parallax bar



Source: Wolf (1974).

p_a – parallax for point a

$p_a = x_a - x'_a = D - (K - r_a) = (D - K) + r_a$

The term D – K is C -- the parallax constant for the setup.

$p_a = C + r_a$

Measuring parallax with parallax bar

- To calculate the parallax of a point, you measure the value r for it with a parallax bar and **Algebraic addition with the** constant c you can do that in stereo for a set of points in few minutes.
- Now, how to compute the constant c ?
- It is computed only once by measuring the parallax of two point monoscopically by measuring their x coordinate on each photo and subtract: $p = x - x_1$
- Now measure the value (r) for each point and apply the equation: $c = p – r$
- You get two values for c, take the average.
- You can use photo centers for this process since the x value of each one on its own photograph is 0, you just need to measure its x value on the other photo

Measuring parallax with parallax bar

- Summary of computation of parallax using a parallax bar:
- Without the bar, using a precise ruler measure the values of x of two points a and b on both photos, well distinctive points
- Calculate the parallax of the two points, where: pa = $x_a - x_a'$ and p_b = Xb-x`b
- Use the parallax bar to measure r_a and r_b fro the same points.
- Compute **C1=** $p_a - r_a$ and **C2=** $p_b - r_b$
- **c** is the average = **(C1+C2)/2**
- For any point measure r with the bar and **Algebraic addition With C** get the parallax

Parallax equations

- Parallax $p = x - x_1$

- $LL_1\ a'\ a_1'$ and $A'\ L\ L_1$ are similar triangles, then

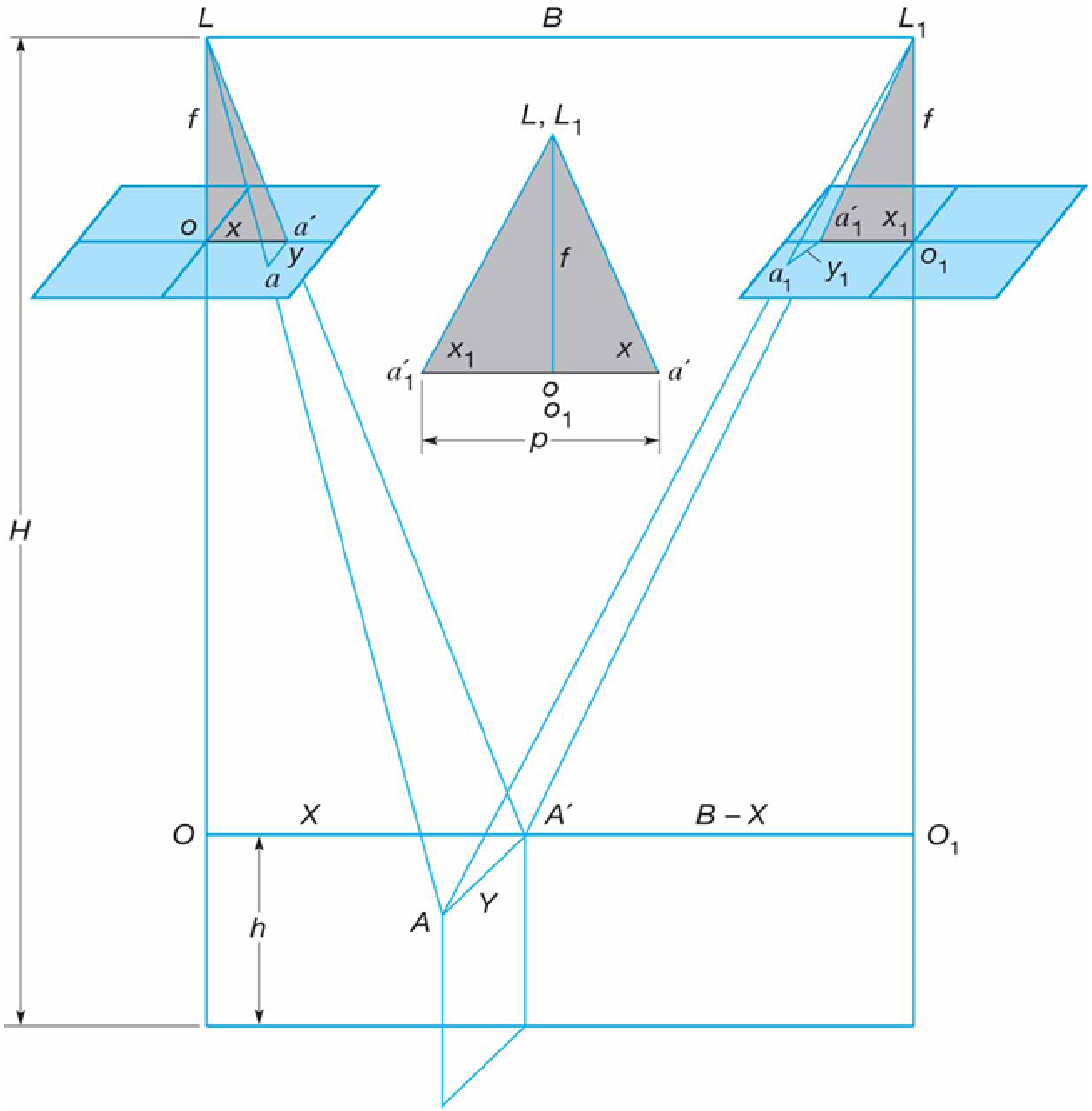
$P / B = f / (H\text{-}h)$, or

$P = f B / (H\text{-}h)$

Also, since the scale = $f / (H\text{-}h)$

then.,

Scale = P / B



Parallax equations

Parallax = p = x left – x1 right= $x - x_1$

$$H\text{-}h = \frac{Bf}{P}$$

get the flying height or point elevation

$$X = \frac{B}{p}x \qquad Y = \frac{B}{p}y$$

get ground coordinates

Therefore,

$$h = H - \frac{Bf}{P}$$

The bigger the parallax, the higher the point

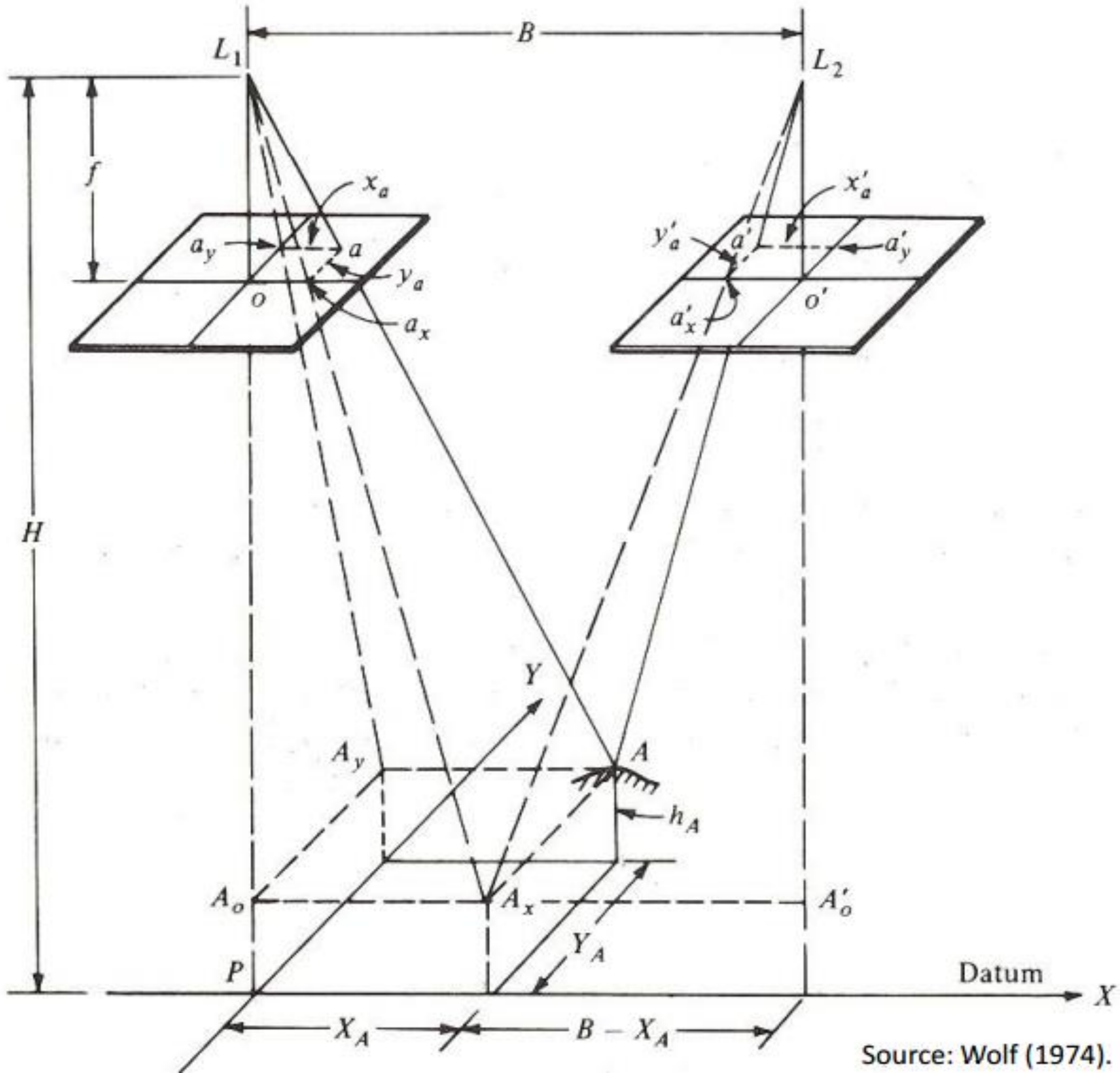
Parallax equations

Ground x, y, and z coordinates can be calculated by u using a paralax.

$h_A = H - Bf/p_a$

$X_A = B * x_a/p_a$

$Y_A = B * y_a/p_a$



Source: Wolf (1974).

Parallax equations

- If we have two points (A & C), we can deliver the formula from the parallax difference between them as follow:

$$h_A = h_C + \frac{\Delta p\ (H - h_C)}{p_a}$$

- $H = h + \frac{Bf}{p}$
- $B = (H - h)\frac{p}{f}$

Example:

A pair of overlapping vertical photographs were taken from a flying height of 4045 feet with a 152.4 mm focal length camera. The air base was1280 feet and parallax bar readings of 12.57 and 13.04 mm were obtained with the floating mark set on principal points (o_l) and (o_2) respectively. If b and b‘ (left and right photo bases) were measured as 93.73 and 93.30mm. Parallax bar readings of 10.96 and 15.27 mm were taken on points A and B. Also the x and y photo coordinates of points A and B were Xa = 53.41 mm, Ya = 50.84mm , Xb= 88.92mm and Yb=-46.69mm Calculate the elevations of points A and B and the horizontal distance between them.

Solution:

Parallax of Point 0_1=P_{o1} = b'= 93.30mm .

Parallax of Point O_2= P_{o2} = b = 93.73mm

Equation of parallax bar: P = c +r $\Rightarrow$ c = P - r

For point 0_1 : **C1=** P_{o1}- r_{o1}=93.30 -12.57 = 80.73mm

For Point 02 : **C2=** P_{02}-r_{02}=93.73 -13.04 = 80.69mm

C average = $\frac{c1+c2}{2} = \frac{80.73+80.69}{2}$=80.71mm.

For point a: P_a = c + r_a= 80.71+ 10.96= 9l.67mm.

For point b : P_b = c + r_b= 80.71+ 15.27= 95.98mm ,

Elevations

$$h_A = H - \frac{f.B}{P_a} = 4045 - \frac{1280x152.4}{91.67} = 1917.02\text{feet}$$

$$h_B = H - \frac{f.B}{P_b} = 4045 - \frac{1280x152.4}{95.67} = 2012.576\text{ feet}$$

$$X = x \, . \, \frac{B}{p}, \qquad Y = y. \, \frac{B}{p}$$

$$X_A = 53.4 \text{ x } \frac{1280}{91.67} = 745.77\text{feet}, \qquad Y_A = 50.84x\frac{1280}{91.67} = 709.885\text{feet.}$$

$$X_B 88.92 \text{ x } \frac{1280}{95.98} = 1185.85\text{feet}, \qquad Y_B = -46.69x\frac{1280}{95.98} = -622.663\text{feet.}$$

Horizontal ground distance AB:

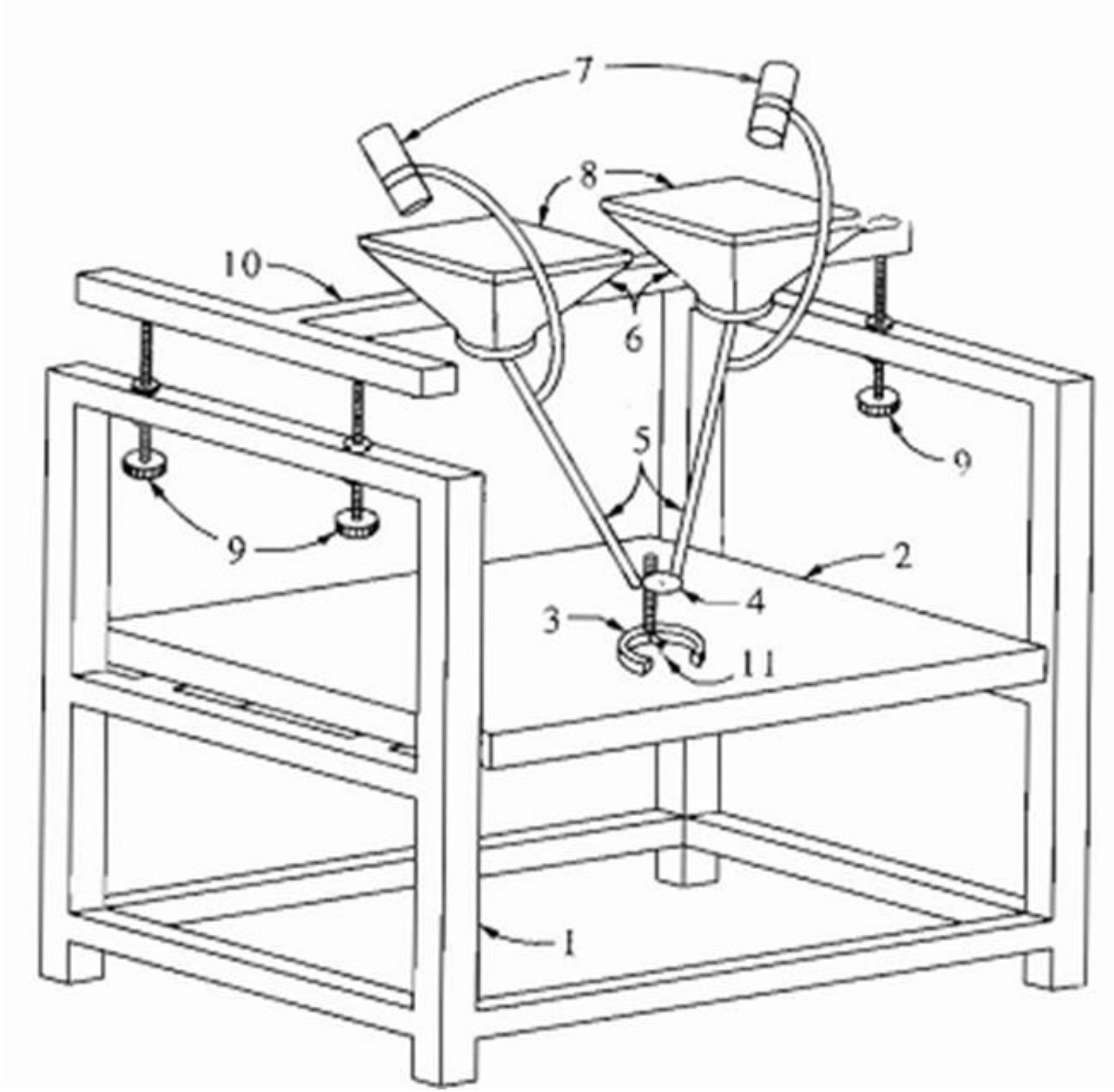
$$AB = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2} = 1403.336 \text{ feet}$$

Stereoscopic plotters

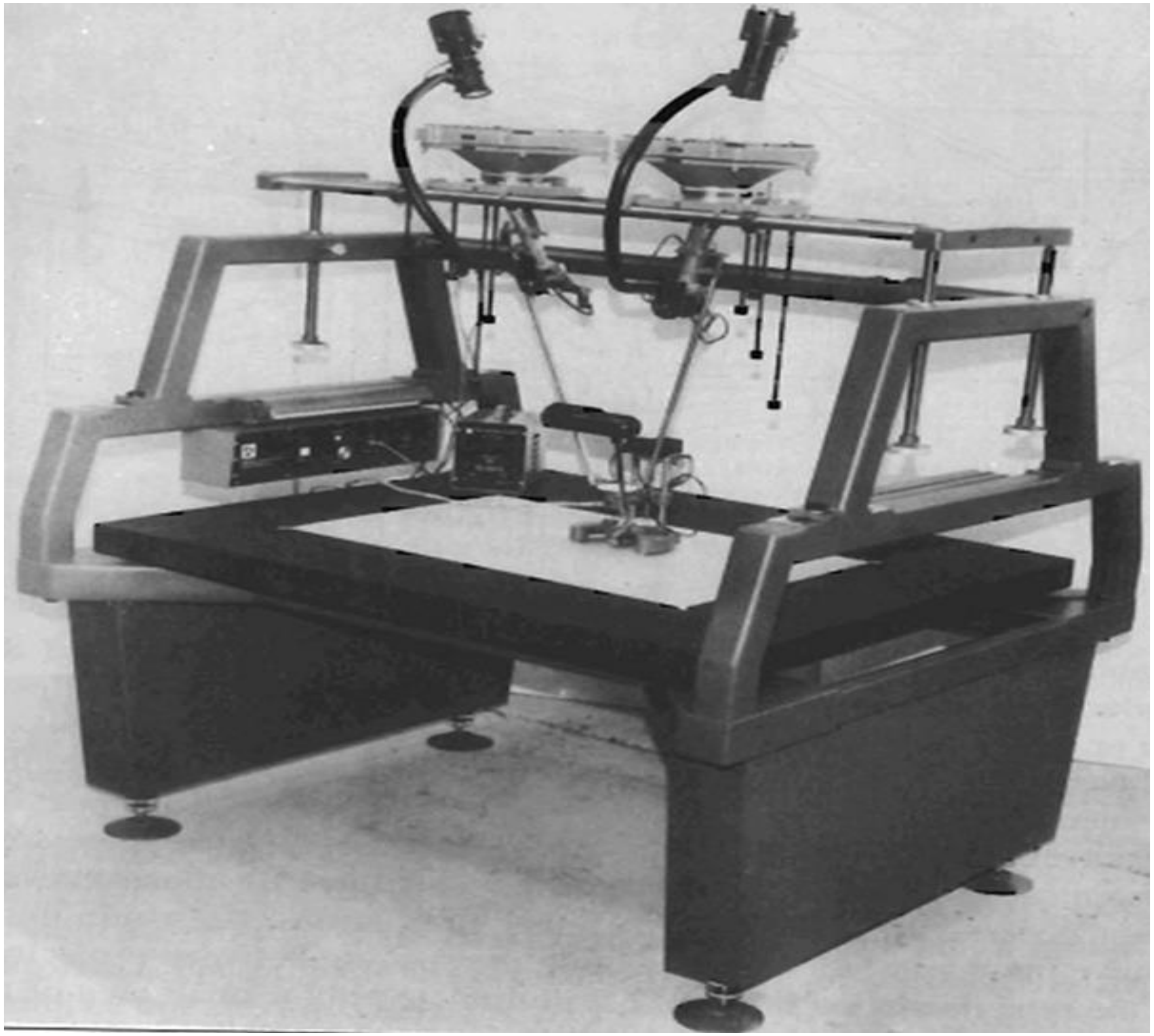
- Stereoscopic plotters are instruments used to measure ground coordinates of points in the overlapped area by measuring their photo coordinates in stereo mode.
- Two overlapping photos are used, either placed in projectors as the case in early models, or displayed in digital format as current technology.
- Such plotters allow for the removal of the Y parallax, the effect of different of scale between the photos, tilt of photos,

Stereo plotters may be classified into three categories:

1- Analogue Optical



Analogue stereoplotter



Analogue stereoplotter

- Film or transparent photos are positioned on the projectors, light is projected through them, their relative positions are adjusted to form a model to scale.
- Points are measured as they are traced on the tracing table (4) in the graph above, a pencil at (11) will draw a map as the tracing table is moved.
- *Such a device is used to illustrate the idea, but not for production today.*

Analytical stereoplotter

- Still uses photographs, but the model is mathematical,
- Two comparators are used to precisely measure photo coordinates, which are recorded digitally.
- The stereo-model is seen through optics as a computer adjusts the photos for stereo viewing and measurements as the mouse is moved by driving servo motors.
- A point is digitized by clicking a mouse when the floating mark rests on it to store the coordinates.
- The digital output is stored and a CAD system can be used to produce a map, on he fly if needed

Analytical stereoplotter

Softcopy photogrammetric workstation

- Softcopy workstations employ digital images, a software, a stereovision system, installed on a powerful computer.
- The output is totally digital, and many operations are automated.
- Softcopy is the current technology used for photogrammetric measurements.
- Images are captured by a digital camera, or scanning photographs.

Photogrammetric workstation


LH Systems

Credits

- **http://www.ccrs.nrcan.gc.ca/ccrs/learn/tutorials/stereosc/chap4/**
- **Engineering Geology**, ETH Zurich
- HU faculty research directory